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DOI:
10.1002/ijgo.12350

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (Harvard):
Abdu, M, Wilson, A, Mhango, C, Taki, F, Coomarasamy, A & Lissauer, D 2018, 'Resource availability for the management of maternal sepsis in Malawi, other low-income countries, and lower-middle-income countries', *International Journal of Gynecology & Obstetrics*, vol. 140, no. 2, pp. 175-183. https://doi.org/10.1002/ijgo.12350

Received: 28 March 2017 | Revised: 25 August 2017 | Accepted: 12 October 2017 | First published online: 08 November 2017

DOI: 10.1002/ijgo.12350

CLINICAL ARTICLE

Obstetrics

WILEY International Journal of Gynecology & Obstetrics FIGO

Resource availability for the management of maternal sepsis in Malawi, other low-income countries, and lower-middle-income countries

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Abstract

Objective: To assess the availability of key resources for the management of maternal sepsis and evaluate the feasibility of implementing the Surviving Sepsis Campaign (SSC) recommendations in Malawi and other low-resource settings.

Methods: A cross-sectional study was conducted at health facilities in Malawi, other low-income countries, and lower-middle-income countries during January–March 2016. English-speaking healthcare professionals (e.g. doctors, nurses, midwives, and administrators) completed a questionnaire/online survey to assess the availability of resources for the management of maternal sepsis.

Results: Healthcare centers (n=23) and hospitals (n=13) in Malawi showed shortages in the resources for basic monitoring (always available in 5 [21.7%] and 10 [76.9%] facilities, respectively) and basic infrastructure (2 [8.7%] and 7 [53.8%], respectively). The availability of antibiotics varied between Malawian healthcare centers (9 [39.1%]), Malawian hospitals (8 [61.5%]), hospitals in other low-income countries (10/17 [58.8%]), and hospitals in lower-middle-income countries (39/41 [95.1%]). The percentage of SSC recommendations that could be implemented was 33.3% at hospitals in Malawi, 30.3% at hospitals in other low-income countries, and 68.2% at hospitals in lower-middle-income countries.

Conclusion: The implementation of existing SSC recommendations is unrealistic in low-income countries because of resource limitations. New maternal sepsis care bundles must be developed that are applicable to low-resource settings.

KEYWORDS

Lower-middle-income countries; Low-income countries; Low-resource settings; Malawi; Maternal sepsis; Resources; Surviving Sepsis Campaign

1 | INTRODUCTION

Maternal sepsis is a life-threatening condition defined as organ dysfunction that results from infection during pregnancy, delivery, or the postabortion or postpartum period.[1] WHO estimates that 303 000 maternal deaths occur worldwide annually, with 99% occurring in low-income countries.[2] Maternal sepsis contributes to 10.7% of these deaths.[3] Sepsis contributes to even more deaths

in some low-income countries, accounting for between 16.3%[4] and 29.4%[5] of maternal mortality in Malawi. To meet the maternal mortality target set out in the Sustainable Development Goals, considerable progress is needed.

In high-income settings, there has been widespread implementation of the Surviving Sepsis Campaign (SSC) guidelines.[6] These guidelines recommend a group of evidence-based interventions aimed at improving the diagnosis and management of sepsis. The interventions include 3-hour and 6-hour "bundles," which represent selected elements of care that—when implemented together—improve outcomes and reduce mortality (odds ratio 0.66; 95% confidence interval 0.61–0.72),[7] although data specific to the maternal population are unavailable. Although effective, doubts exist regarding their applicability in low-resource settings.[8] The feasibility of implementing the SSC guidelines has not previously been examined in low-resource settings and would be critical in future attempts to produce guidance suitable for such settings.

There are several key elements that make the SSC guidelines clinically effective. Alongside the 3 and 6-hour bundles, the "key resources" needed for the initial management of maternal sepsis are fluids, antibiotics, basic monitoring (blood pressure, pulse, temperature), and basic infrastructure (water, sanitation, hygiene).[9] These have been highlighted as the cornerstones of effective sepsis management in any setting.[10] Better understanding of their availability is critical in planning programmatic interventions to improve sepsis outcomes in low-income and lower-middle-income settings.

Malawi was the focus of the current project; it is an example of a country with a high sepsis morbidity and mortality.[4,5] It has been selected as the location for a feasibility study examining the introduction of a maternal sepsis bundle designed specifically for use in the maternity population in low-income countries. This will form part of a wider WHO maternal sepsis program.[11]

The present study aimed to investigate the perceived availability of key resources for maternal sepsis management and SSC guideline/bundle implementation in health centers and hospitals in Malawi, and to compare resource availability across hospitals in Malawi, other low-income countries, and lower-middle-income countries.

2 | MATERIALS AND METHODS

Data were collected using a self-reported, cross-sectional survey of healthcare professionals in maternal healthcare facilities, conducted between January 31 and March 31, 2016. The study questionnaire (Appendix S1) was distributed to healthcare professionals from 21 healthcare facilities in Blantyre, Malawi, and in an online survey targeting all 82 low-income and lower-middle-income countries as classified by the World Bank. In Malawi, all facilities providing maternity care in Blantyre were sampled. Any healthcare professional involved in maternal health care at the time of the questionnaire distribution was invited to participate using a paper-based, structured questionnaire to assess maternal sepsis management resources. For the online survey, snowball sampling was used and internet searches were conducted to identify relevant international obstetrics and gynecology organizations, healthcare facilities, and professionals active in the field through published literature in the relevant countries. Snowball sampling is a nonprobability sampling technique whereby existing study participants recruit further study participants; therefore, response rate calculations are inappropriate.

Participants were informed that completion of the questionnaire or online survey constituted consent. Ethics approval was obtained from the University of Birmingham (Birmingham, UK) and from the College of Medicine in Blantyre, Malawi.

Healthcare professionals included doctors, nurses, midwives, and administrators among others. All healthcare professionals were required to read and write English to complete the questionnaire (or online survey). Any healthcare professional who was a US citizen was excluded from participating because the University of Birmingham was unable to cover potential liability for their involvement.

The questionnaire and online survey (conducted using SmartSurvey [SmartSurvey, Tewkesbury, UK]) provided self-reported assessments of the perceived availability of key resources required for managing maternal sepsis and SSC guideline implementation. The questionnaire was adapted from that used by Baelani et al.,[12] who investigated the availability of resources to implement the 2008 SSC guidelines among anesthetists. The resources required to implement each of the latest 2012 SSC guideline recommendations[6] and other key resources[9,10] were identified by consensus among the research team. Resources were classified as "always," "sometimes," or "never" available, or as "don't know." Only resources considered to be "always" available were deemed sufficient to consistently implement the SSC guidelines.

The "key resources" investigated in the current analysis (fluids, antibiotics, basic monitoring, and basic infrastructure) have been highlighted as essential in the initial management of maternal sepsis.[9,10] "Basic monitoring" includes measurement of the blood pressure, pulse, respiratory rate, and temperature. "Basic infrastructure" includes the availability of water, sanitation, and hygiene services,[13] specifically the availability of clean gloves, running water, skin cleaning preparation, soap, and alcohol gel.

Moreover, several "additional resources" central to other internationally recommended sepsis bundles[9,14] were investigated, including oxygen therapy and measurement of oxygen saturation and lactate. The 3-hour bundle of the SSC guideline includes lactate measurement, blood culture testing, administration of antibiotics, and management of hypotension. The 6-hour sepsis bundle includes the administration of vasopressors and lactate re-measurement.

The questionnaire and survey underwent pilot testing by the research team and by obstetricians and gynecologists at Birmingham Women's Hospital, Birmingham, UK. All questionnaire and survey materials were written in English because all healthcare professionals in Malawi are trained in English. All responses were anonymous.

In the 2012 SSC guidelines,[6] 29 (30.5%) of the 95 recommendations are either passive ("do not use") or require no resources for their implementation. These passive recommendations were not assessed in the present data analysis. The results shown in this manuscript illustrate the ability of facilities to implement the remaining 66 SSC recommendations.

The questionnaire and survey responses were categorized into responses from facilities in Malawi, other low-income countries, and lower-middle-income countries. The planned comparisons were between facility types within Malawi, between hospitals in Malawi and other low-income countries, and between hospitals in low-income and lower-middle-income countries.

The statistical analysis was conducted using SPSS version 22.0 (IBM, Amonk, NY, USA). The respondents from Malawi were grouped on the basis of their type of facility, and the mean percentage of implementable SSC recommendations per facility type was calculated. If there were two respondents from the same facility, the more conservative response was used. If there were more than two respondents from a facility, the mode of their responses regarding the reported availability of that resource was used to represent that facility. Tests of normality were conducted using the Shapiro-Wilk test with a priori comparisons conducted between nonparametric continuous data using the Mann-Whitney *U* test, and between categorical data using the Fisher exact test. $P<0.05$ was considered statistically significant.

3 | RESULTS

Study invitations were sent to 77 of the 82 low and lower-middle income countries, receiving responses from 94 facilities. A total of 36 facilities were in Malawi; 21 facilities' responses were collected via questionnaire distribution in Blantyre, Malawi, and another 15 facilities responded via the online survey (total 23 health centers and 13 hospitals). The other 58 facilities were based in 31 other low-income or lower-middle-income countries. Table S1 provides a summary of the facility characteristics and Table S2 provides an overview of the responding countries. Of the 161 questionnaire/survey respondents, 112 (69.6%) had been involved in the care of a patient with maternal sepsis in the preceding month. In Blantyre, the 45 respondents were either midwives (n=30 [66.7%]), medical assistants (n=10 [22.2%]), or medical technicians (n=5 [11.1%]).

Key resources required for the management of maternal sepsis were assessed at all facilities. Fluids were available in 28 (77.8%) of the 36 Malawian facilities (Table 1). However, the availability of other resources was poor, with antibiotics available in 17 (47.2%) facilities, basic monitoring in 15 (41.7%) facilities, and basic infrastructure in 9 (25.0%) facilities. The availability of antibiotics was significantly greater in Malawian private health centers than in public health centers ($P=0.006$) (Table 1). Compared with Malawian health centers, Malawian hospitals had a larger percentage of facilities where all key resources were available ($P=0.047$), a greater availability of basic infrastructure resources ($P=0.041$), and a greater availability of basic monitoring resources ($P=0.009$) (Table 1).

Despite an overall poor availability of resources, there was great variation between the facilities within Malawi. Facilities in the largest districts (Lilongwe, Blantyre, and Mzuzu [central hospitals]) had a greater availability of key resources than did hospitals in smaller, more rural districts (Fig. 1). In Blantyre, facilities closer to the center of town had greater resource availability than did more-peripheral facilities (Fig. 1).

The percentage of hospitals with all key resources available was greatest in lower-middle-income countries, followed by low-income counties and Malawi (Table 2). Although hospitals in lower-middle-income countries and low-income countries had similar availability of the key resources for basic monitoring and infrastructure, fluids and antibiotics were significantly more often available in hospitals in lower-middle-income countries (Fig. 2).

In terms of the availability of additional resources within Malawian healthcare facilities, oxygen therapy was as often available as some of the key resources (15 [41.7%] healthcare facilities). Oxygen saturation and lactate were less readily available (10 [27.8%] facilities and 2 [5.6%] facilities, respectively). The percentage of hospitals with all additional resources available was greatest in lower-middle-income countries, followed by low-income counties and finally Malawi (Table 2).

On average, Malawian healthcare facilities were able to implement 20.7% (range 1.5%–65.2%) of the 2012 SSC recommendations; elements critical for the SSC 3-hour and 6-hour sepsis bundles were scarcely available (Table 1). Malawian private healthcare centers were able to implement a significantly higher percentage of SSC recommendations compared with public healthcare centers ($P=0.003$) (Table 1). Malawian hospitals had resources to implement 33.3% of the SSC guideline recommendations; this percentage was significantly higher than the percentage of recommendations that could be implemented at Malawian health centers (11.4%, $P=0.001$) (Table 1).

Hospitals in lower-middle-income countries were able to implement a higher percentage of SSC recommendations than hospitals in Malawi or in low-income countries (Table 2, Fig. 2). Compared with hospitals in low-income countries, hospitals in lower-middle-income countries also had a greater ability to implement elements of the SSC 3-hour and 6-hour sepsis bundles, including antibiotics and vasopressors (Table 2).

4 | DISCUSSION

To our knowledge, the present study is the first to evaluate the availability of recognized key resources for the management of maternal sepsis in Malawi and across other low-income and lower-middle-income countries. The findings show that low-income countries have severe limitations in the availability of resources for the management of maternal sepsis. This has important implications for the safe delivery of maternal health care.

Regarding elements that make the SSC recommendations clinically effective, the timely administration of antibiotics is vital and improves mortality outcomes.[8,15] However, the availability of antibiotics varied between hospitals in lower-middle income countries (95.1%), hospitals in low-income countries (58.8%), and health centers in Malawi (39.1%). Efforts to increase the availability of antibiotics in low-income settings and to allow the rapid initiation of effective treatment should be a priority. More promisingly, fluid resuscitation—another mainstay of sepsis management[8]—was more widely available in hospitals

TABLE 1 Availability of key resources for the management of maternal sepsis and percentage of implementable SSC guideline recommendations in Malawi.[a]

Variable	Public vs private health centers			Health centers vs hospitals		
	Public health centers (n=18)	Private health centers (n=5)	*P* value[b]	All health centers (n=23)	All hospitals (n=13)	*P* value[b]
Availability of key resources						
All key resources available	0	1 (20.0)	0.217	1 (4.3)	4 (30.8)	0.047[c]
Intravenous fluids			>0.99			
Always	14 (77.8)	4 (80.0)		18 (78.3)	10 (76.9)	>0.99
Sometimes	3 (16.7)	1 (20.0)		4 (17.4)	3 (23.1)	
Never	1 (5.6)	0		1 (4.3)	0	
Broad-spectrum antibiotics			0.006[c]			
Always	4 (22.2)	5 (100.0)		9 (39.1)	8 (61.5)	0.481
Sometimes	12 (66.7)	0		12 (52.2)	5 (38.5)	
Never	2 (11.1)	0		2 (8.7)	0 (0.0)	
Basic monitoring			>0.99			
Always	3 (16.7)	2 (40.0)		5 (21.7)	10 (76.9)	0.009[c]
Sometimes	8 (44.4)	3 (60.0)		11 (47.8)	2 (15.4)	
Never	7 (38.9)	0		7 (30.4)	1 (7.7)	
Basic infrastructure			0.450			
Always	1 (5.6)	1 (20.0)		2 (8.7)	7 (53.8)	0.041[c]
Sometimes	11 (61.1)	3 (60.0)		14 (60.9)	6 (46.2)	
Never	6 (33.3)	1 (20.0)		7 (30.4)	0 (0.0)	
Availability of additional resources						
All additional resources available	0	1 (20.0)	0.217	1 (4.3)	2 (15.4)	0.539
Oxygen therapy			>0.99			
Always	3 (16.7)	2 (40.0)		5 (21.7)	10 (76.9)	0.331
Sometimes	2 (11.1)	1 (20.0)		3 (13.0)	2 (15.4)	
Never	13 (72.2)	2 (40.0)		15 (65.2)	1 (7.7)	
Oxygen saturation			>0.99			
Always	1 (5.6)	2 (40.0)		3 (13.0)	7 (53.8)	>0.99
Sometimes	1 (5.6)	0		1 (4.3)	5 (38.5)	
Never	16 (88.9)	3 (60.0)		19 (82.6)	1 (7.7)	
Lactate monitoring			>0.99			
Always	0	1 (20.0)		1 (4.3)	1 (7.7)	>0.99
Sometimes	1 (5.6)	0 (0.0)		1 (4.3)	3 (23.1)	
Never	17 (94.4)	4 (80.0)		21 (91.3)	9 (69.2)	
Implementation of SSC guidelines						
Implementation of all recommendations possible	0	1 (20.0)	0.217	0	0	NA
Percentage of implementable recommendations	10.6 (7.6–13.6)	24.2 (18.2–46.3)	0.003[c]	11.4 (8.6–21.2)	33.3 (20.5–43.2)	0.001[c]
Percentage of implementable Grade 1 recommendations	18.5 (14.8–25.9)	40.7 (30.6–63.0)	0.004[c]	22.2 (17.3–33.3)	44.4 (29.0–57.4)	0.008[c]
Percentage of implementable Grade 2 recommendations	3.1 (1.6–3.1)	12.5 (7.1–29.7)	0.001[c]	9.4 (0.0–14.3)	21.9 (10.2–32.7)	0.026[c]
Percentage of implementable ungraded recommendations	6.0 (0.0–14.3)	28.6 (14.2–57.2)	0.018[c]	14.0 (0.0–21.5)	35.8 (25.0–54.5)	0.001[c]
3-hour sepsis bundle						
Implementation of entire bundle possible	1 (4.3)	1 (7.7)	0.395	1 (4.3)	1 (7.7)	>0.99
Bundle element "lactate"	0	1 (20.0)	0.217	1 (4.3)	1 (7.7)	>0.99

(Continues)

TABLE 1 (Continued)

Variable	Public vs private health centers			Health centers vs hospitals		
	Public health centers (n=18)	Private health centers (n=5)	*P* value[b]	All health centers (n=23)	All hospitals (n=13)	*P* value[b]
Bundle element "blood culture"	0	1 (20.0)	0.217	1 (4.3)	3 (23.1)	0.124
Bundle element "antibiotics"	4 (22.2)	5 (100.0)	0.004[c]	9 (39.1)	8 (61.5)	0.299
Bundle element "hypotension"	6 (33.3)	4 (80.0)	0.127	10 (43.5)	9 (69.2)	0.177
6-hour sepsis bundle						
Implementation of entire bundle possible	0	1 (20.0)	0.217	1 (4.3)	1 (7.7)	>0.99
Bundle element "vasopressors"	2 (11.1)	3 (60.0)	0.048[c]	5 (21.7)	9 (69.2)	0.011[c]
Bundle element "CVP/$ScvO_2$"	4 (22.2)	3 (60.0)	0.142	7 (30.4)	10 (76.9)	0.014[c]
Bundle element "remeasure lactate"	0	1 (20.0)	0.217	1 (4.3)	1 (7.7)	>0.99

Abbreviations: SSC, Surviving Sepsis Campaign; CVP, central venous pressure; $ScvO_2$, central venous oxygen saturation.

[a]Values are given as number (percentage) or median percentage (interquartile range).

[b]Few respondents chose the "never" option invalidating the χ^2 test; therefore, only "always" and "sometimes" responses were included in the statistical analysis.

[c]Significant group difference.

in lower-middle-income countries (95.1%) and low-income countries (70.6%). Similarly, the availability of antibiotics within healthcare centers in Malawi (39.1%) was significantly lower than the availability of fluid resuscitation (78.3%).

The sepsis "bundles" form the core of the SSC's improvement efforts. Nevertheless, critical items required for these bundles were scarcely available in hospitals in Malawi and other low-income countries. Lactate measurement and blood culture were the most limiting components of the 3-hour bundle, particularly at Malawian health centers.

The results of the present study support previous reports from healthcare professionals that health facilities in Malawi[16] and other

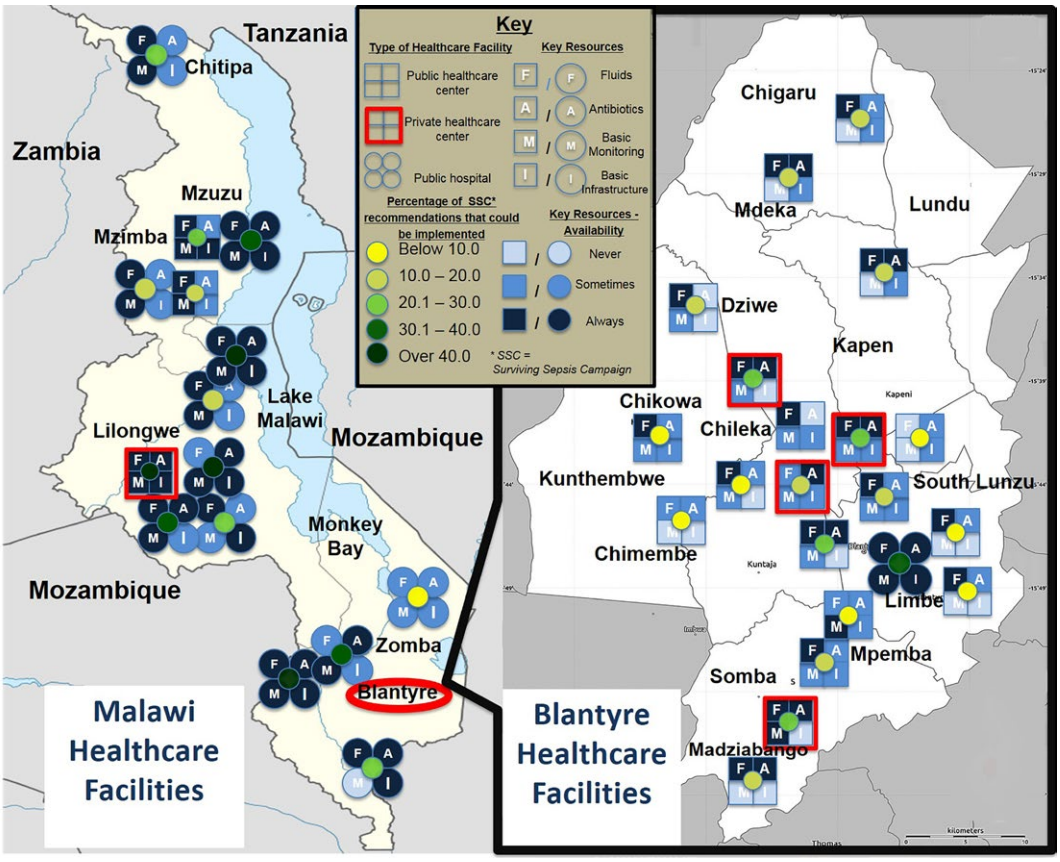

FIGURE 1 Availability of key resources for the management of maternal sepsis and percentage of SSC guideline recommendations that could be implemented in Malawi. Abbreviation: SSC, Surviving Sepsis Campaign.

TABLE 2 Comparison of the availability of key resources for the management of maternal sepsis and percentage of implementable SSC guideline recommendations between hospitals in Malawi, other low-income countries, and lower-middle-income countries.[a]

Variable	Malawi (n=13)	Other low-income countries (n=17)	Lower-middle-income countries (n=41)	*P* value[b]	
				Malawi vs other low-income countries	Other low-income vs lower-middle-income countries
Availability of key resources					
All key resources available	4 (30.8)	8 (47.1)	30 (73.2)	0.465	0.073
Intravenous fluids				>0.99	0.019[c]
Always	10 (76.9)	12 (70.6)	39 (95.1)		
Sometimes	3 (23.1)	5 (29.4)	2 (4.9)		
Never	0	0	0		
Broad-spectrum antibiotics				>0.99	0.002[c]
Always	8 (61.5)	10 (58.8)	39 (95.1)		
Sometimes	5 (38.5)	7 (41.2)	2 (4.9)		
Never	0	0	0		
Basic monitoring				>0.99	0.681
Always	10 (76.9)	14 (82.4)	36 (87.8)		
Sometimes	2 (15.4)	3 (17.6)	5 (12.2)		
Never	1 (7.7)	0	0		
Basic infrastructure				0.255	0.737
Always	7 (53.8)	13 (76.5)	32 (78.0)		
Sometimes	6 (46.2)	4 (23.5)	8 (19.5)		
Never	0	0	1 (2.4)		
Additional resources					
All additional resources available	2 (15.4)	4 (23.5)	15 (36.6)	0.672	0.377
Oxygen therapy				>0.99	>0.99
Always	10 (76.9)	15 (88.2)	35 (85.4)		
Sometimes	2 (15.4)	2 (11.8)	4 (9.8)		
Never	1 (7.7)	0	2 (4.9)		
Oxygen saturation				>0.99	0.308
Always	7 (53.8)	10 (58.8)	30 (73.2)		
Sometimes	5 (38.5)	6 (35.3)	8 (19.5)		
Never	1 (7.7)	1 (5.9)	3 (7.3)		
Lactate monitoring				>0.99	0.266
Always	1 (7.7)	4 (23.5)	16 (39.0)		
Sometimes	3 (23.1)	6 (35.3)	9 (22.0)		
Never	9 (69.2)	7 (41.2)	16 (39.0)		
Implementation of SSC guidelines					
Implementation of all recommendations possible	0	0	0	NA	NA
Percentage of implementable recommendations	33.3 (20.5–43.2)	30.3 (20.5–64.4)	68.2 (47.0–85.6)	0.402	0.005[c]
Percentage of implementable Grade 1 recommendations	44.4 (29.0–57.4)	40.7 (24.1–79.7)	85.2 (63.0–95.4)	0.557	0.003[c]
Percentage of implementable Grade 2 recommendations	21.9 (10.2–32.7)	25.0 (12.5–54.7)	59.4 (29.7–76.6)	0.258	0.011[c]
Percentage of implementable ungraded recommendations	35.8 (25.0–54.5)	42.9 (28.6–64.3)	71.4 (50.0–85.7)	0.272	0.011[c]

(Continues)

TABLE 2 (Continued)

Variable	Malawi (n=13)	Other low-income countries (n=17)	Lower-middle-income countries (n=41)	*P* value[b]	
				Malawi vs other low-income countries	Other low-income vs lower-middle-income countries
3-hour sepsis bundle					
Implementation of entire bundle possible	1 (7.7)	3 (17.6)	16 (39.0)	0.613	0.137
Bundle element "lactate"	1 (7.7)	4 (23.5)	16 (39.0)	0.355	0.366
Bundle element "blood Culture"	3 (23.1)	7 (41.2)	29 (70.7)	0.440	0.043[c]
Bundle element "antibiotics"	8 (61.5)	10 (58.8)	39 (95.1)	>0.99	<0.001[c]
Bundle element "hypotension"	9 (69.2)	11 (64.7)	38 (92.7)	>0.99	0.014[c]
6-hour sepsis bundle					
Implementation of entire bundle possible	1 (7.7)	2 (11.8)	15 (36.6)	>0.99	0.111
Bundle element "vasopressors"	9 (69.2)	10 (58.8)	35 (85.4)	0.708	0.040[c]
Bundle element "CVP/$ScvO_2$"	10 (76.9)	14 (82.4)	37 (90.2)	>0.99	0.407
Bundle element "remeasure lactate"	1 (7.7)	4 (23.5)	16 (39.0)	0.355	0.366

Abbreviations: SSC, Surviving Sepsis Campaign; CVP, central venous pressure; $ScvO_2$, central venous oxygen saturation.
[a]Values are given as number (percentage) or median percentage (interquartile range).
[b]Few respondents chose the "never" option invalidating the χ^2 test; therefore, only "always" and "sometimes" responses were included in the statistical analysis.
[c]Significant group difference.

low-income countries[12] lack critical resources required to implement the SSC guidelines and manage maternal sepsis. This lack of sepsis resources could be an important contributor to Malawi's high maternal mortality rate.[17] It is important to acknowledge that maternal sepsis is also one of the reasons why pregnant women with HIV infection have a greater risk of death than their uninfected counterparts.[18] Therefore, the contribution of untreated HIV infections and the shortage of antiretroviral drugs to Malawi's mortality rate must be tackled concurrently with addressing issues surrounding sepsis care.[19]

To improve the outcomes of maternal sepsis, prompt identification of this condition and immediate initiation of care are required. A bundle-based approach has proven effective in other settings,[7] but an essential principle of the success of this approach is that all elements must be available and used in every eligible patient.[20] With the current SSC bundles, this is clearly not feasible in low-income and

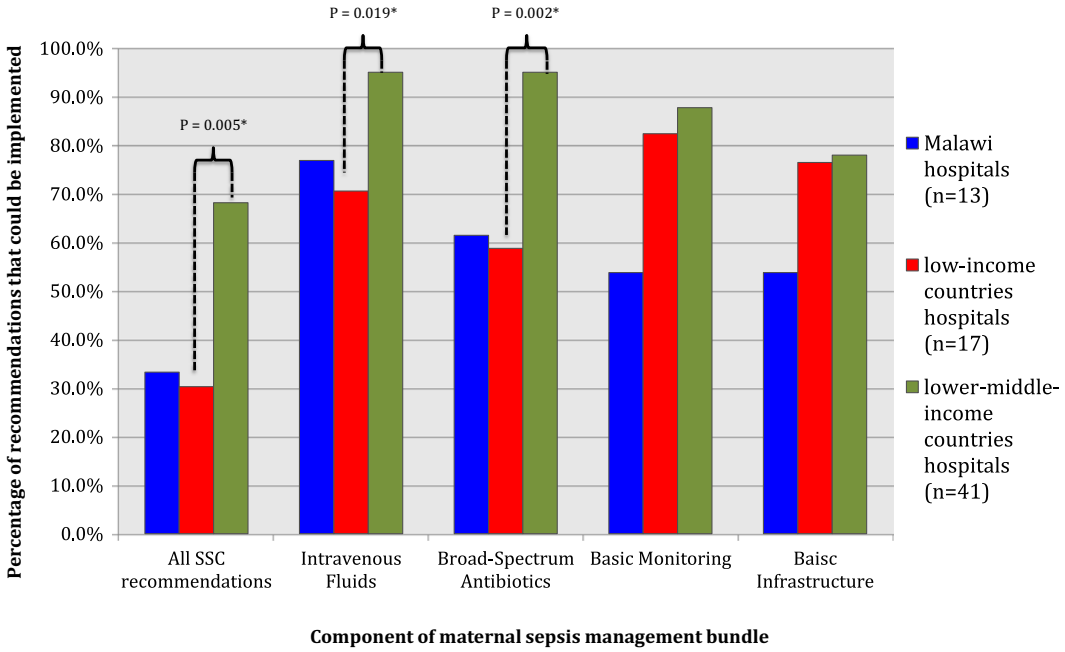

FIGURE 2 Percentage of SSC guideline recommendations that could be implemented at hospitals in Malawi, other low-income countries, and lower-middle-income countries. Abbreviation: SSC, Surviving Sepsis Campaign.

lower-middle-income settings. Previous research[8] has indicated that these bundles need to be adapted for use in low-resource settings. To be able to initiate care early, the adapted bundles should ideally be deliverable not only in hospital settings but also within community-based healthcare centers where patients present initially.[21] To improve sustainability and maximize coverage, the development of new low-resource maternal sepsis bundles should be rigorous, have wide involvement from practitioners delivering care in this setting, and be grounded in a realistic assessment of the available resources.[22]

The limited and inconsistent supply of resources demonstrated by the present study is probably a reflection of weak systems, with widespread limitations across all aspects of resource provision rather than those related to maternal sepsis only.[23] Quality improvement approaches that aim to address the limitation in resources for the management of maternal sepsis will therefore need to be integrated into, and matched by, wider health system strengthening initiatives and international advocacy efforts.[24,25]

The present study has several limitations. The availability of resources was assessed subjectively by care providers, rather than through an objective evaluation of the resources available or used in the management of maternal sepsis. The availability of human resources and organizational systems that are vital to delivery of appropriate sepsis care was not examined. The use of an online survey limited the responding sites to those with internet access, which might comprise facilities with better resources, resulting in an over-representation of facilities with good resources. Although invitations were sent to 77 of the 82 low-income and lower-middle-income countries recognized by the World Bank, the present analysis encompassed data collected from 32 countries only, limiting the representativeness of the results. Malawi aside, where 36 facilities responded, 58 facilities responded across the other 31 countries. Therefore, the present results cannot be generalized to all sites within these countries, given that there will be variability between the facilities and over time.

In conclusion, implementation of the existing SSC guidelines or bundles is unrealistic in most facilities in Malawi and other low-income countries because of severe resource limitations; facilities in lower-middle-income countries are more adequately resourced. The present work highlights the urgent need to improve the provision of broad-spectrum antibiotics, the availability of basic monitoring equipment, and the basic hygiene infrastructure in facilities in low-income countries. New maternal sepsis bundles should be developed that take account of the actual availability resources in low-income countries, to make it feasible to implement the bundles in these countries' health centers and hospitals.

AUTHOR CONTRIBUTIONS

MA conducted the primary data collection, analyzed the data, and drafted the manuscript. CM assisted with the data collection and managed the study in Malawi. DL conceived the study. AW, AC, FT, and DL planned and supervised the study. All authors reviewed and edited the manuscript.

ACKNOWLEDGMENTS

Funding was provided by the University of Birmingham, Birmingham, UK. The Worshipful Company of Haberdashers, London, UK, provided funding for travel for MA.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

Table S1. Characteristics of the healthcare facilities included in the present survey.

Table S2. List of responding countries.

Appendix S1. Resource availability questionnaire.